DRAFT 12/5/2016

Review of SWRCB's "Working Draft Scientific Basis Report for New and Revised Flow Requirements on the Sacramento River and Tributaries, Eastside Tributaries to the Delta, Delta Outflow, and Interior Delta Operations"

Delta Independent Science Board

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Preamble

The State of California has an enduring responsibility to balance management of California's waters for sometimes conflicting purposes. This certainly applies to the State Water Resources Control Board (SWRCB) policies affecting flows and diversions affecting the Sacramento-San Joaquin Delta (Delta). The Delta Independent Science Board (Delta ISB) has been asked to review the SWRCB's *Working Draft Scientific Basis Report for New and Revised Flow Requirements on the Sacramento River and Tributaries, Eastside Tributaries to the Delta, Delta Outflow, and Interior Delta Operations*, 2016. The purpose of this review is to examine the science strategy taken by the SWRCB, particularly the mustering and development of scientific information to provide the "best available science" for making policy decisions which balance water management policies across management objectives.

This review is programmatic and not detailed. We used questions asked by the SWRCB to guide our review. Short answers to these questions are provided in Appendix A. We expect that others will minutely scrutinize the literature and detailed findings of this report for ambiguity, conflicting scientific findings, missing scientific evidence, edits, and interpretations of scientific results.

Here, we seek to review the overall scientific basis approach proposed by the SWRCB in their draft and how it might be improved or adapted to improve the scientific basis for discussions and regulations of environmental and ecosystem aspects of flows and over stressors in the Delta and its tributaries. It is clear that of the many findings in the SWRCB report, at least some will turn out to be wrong in some large or small way as science advances. This is the nature of scientific knowledge. It is sometimes imperfect, especially in new fields, and should be viewed as a process for improving knowledge, rather than merely stating current knowledge in an absolute way. For all its faults, scientific knowledge is generally better than the intuitions of all but the luckiest people, especially in controversial areas where perceptions are often swayed by interests and fears.

Major comments

Overall, we found the report draft to be well-written, useful, and highly informative but suggest some substantive improvements.

1. Comparative Scientific Basis for Unimpaired Flow-based Standards

The report provides fish life history understanding and statistical correlations to argue that natural flows should be beneficial to native species. The SWRCB has chosen to base its default ecosystem flow standards as a percent of unimpaired flows, as an approximation to more natural flows. In implementing this regulation, the SWRCB has shown a clear preference for regional agreements between stakeholders and the SWRCB, that may deviate from a strict proportion of daily, weekly, or monthly unimpaired flow. The proposed unimpaired flow approach is relatively easy to administer and seems to allow flexibility in working with regional interests and diverse regulators, water projects, and water users to pool their potentially diverse authorities to implement diverse operational and management activities to benefit native species and human water users. We recommend that the report include a stronger discussion of the rationale for using an unimpaired flow basis compared with alternative approaches, such as functional flows which provide a more mechanistic approach to estimating flow needs and tradeoffs.

Alternative scientific approaches to establishing environmental flows.
Several approaches are available in the scientific literature for establishing flow requirements for fish and aquatic ecosystems. All have advantages and drawbacks, and can be used together, or in conjunction with other approaches.

<u>Natural flows</u> (or "natural flow doctrine") are the simplest approach for specifying ecological flow needs. Flow rate as well as timing, variance, extremes (e.g. flooding) and route complexity are all important components of natural flow. As the document and many others have observed, the native ecosystem evolved in the flows that naturally occurred for thousands of years. So managing flows to approximate such natural flows should give some hope for supporting native species and ecosystems.

This approach is conceptually easy, but it has some drawbacks. First, existing native species often find themselves in a system altered in many ways, with altered flow patterns, greatly contracted and disrupted habitat areas (especially loss of floodplain habitats), and in an environment replete with numerous non-native species and human-introduced chemicals.

There will often be cases where restoration of natural flows will be inadequate to restore native ecosystems. Additional actions, such as habitat expansion or improvement, invasive species management, or contaminant management, might be needed for existing or increased flows to be effective in supporting native species. There is also a likelihood that certain native ecosystems are irrevocably altered to the point where some species cannot be saved in the wild.

Often unimpaired flows are used for flow regulation in lieu of natural flows. Unimpaired flows usually represent the total flow available to be managed and might not be the quantities or qualities which naturally flowed in the region - natural flows. In systems with formerly extensive flood plains and wetlands or higher groundwater tables, such as California's Central Valley, natural flows can substantially differ from unimpaired flows (DWR 2016; Fox et al. 2015). But estimating unimpaired flows is far easier than modeling the many pre-development conditions that resulted in natural flows. And with climate change and many other unalterable landscape and species changes since pre-development times, it is not clear that precise estimation of natural flows is particularly relevant.

<u>Regression or statistical analysis</u> is a more formal empirical approach for estimating environmental flow needs. These are popular where data on flows and fish can be correlated statistically. These analyses are common in the SWRCB report, and show that populations of many native and non-native species are correlated with streamflows in, around, and out of the Delta. Indeed, the statistical evidence is compelling that many native species benefit from additional streamflows at some times and locations, either directly or from additional habitat that comes from greater inundations. The SWRCB has nicely provided some discussion of plausible mechanistic explanations for many of the broad relationships revealed statistically.

Although statistical analysis can be insightful and is relatively quick and easy, it too suffers from drawbacks. As is often said, "correlation is not causation," and there are many cases where complex and simple statistical analyses have led policies astray. Some correlations are spurious.

The changing species composition of the estuary and particularly the dominance of certain invasive species means that fundamental ecological relationships among a changing species composition will affect resulting statistical relationships. Such changes in species composition, as well as changes in chemical discharges and runoff and climate change (particularly temperature), mean that regressions from past data often have diminishing predictive accuracy and value into the future.

Functional flows is a more mechanistic approach to estimating flow needs and trade-offs (Yarnell et al. 2015; DISB 2015). While fish obviously need water, their ecosystems need different amounts of water and habitat at different times and locations for different stages of their life cycles. Mechanistic approaches to estimating these flows are based on field observations of flows needed for observable life stages and computer models of hydrodynamics, habitat, and ecological conditions for different flows. Environmental flows are then based on the functional flows needed to support different ecological functions and life stages of various species in the ecosystem. Such mechanistic modeling has been successful for other major aquatic systems (DISB 2016), but has not been energetically developed for California's inland fishes.

The advantages of more mechanistic and causal approaches to establishing flow requirements are their greater ability to explain success and failure and their ability to absorb new knowledge, perhaps responding to past inaccuracies. Mechanistic approaches seem especially desirable where implementations are negotiated and success is uncertain, implying an enduring need to test and update implementation, hopefully based on organized and improving science (adaptive management). However, mechanistic approaches require prolonged and dedicated organization, funding, and modeling and research efforts to develop the component functional flows, and improve them over time.

Unimpaired flows.

The SWRCB has chosen to base its default flow standards on a fraction of unimpaired flows, the latter being largely dependent on inputs such as precipitation and snow melt. CalSIM II is used to obtain the present flow conditions and Sacramento Valley Unimpaired Flow Model (SVUFM) is used to estimate the details of unimpaired flow for different water years. This approach is not without justification. It is simple and is a rough approximation to the understandable natural flows approach to setting flow standards. It is relatively fast to implement and has relatively few complications and technical back alleys in its implementation to attract technical controversy. Moreover, the SWRCB's approach to implementing an unimpaired flow percentage based standard seems to allow considerable flexibility in working with regional interests for the benefit of both native species and human water users.

In effect, the proposed unimpaired flow basis for environmental flows is a convenient accounting approach or environmental water budget for this more flexible implementation. This flexibility might be its greatest virtue. The approach also varies this environmental water budget roughly with natural hydrologic conditions between years. The SWRCB might also establish an upper value for environmental flows, above which additional flows might be increasingly or entirely diverted or stored.

Given the absence of extensive data, numerical models become important for defining unimpaired and impaired flows. Some models, such as, CalSim II, have gone through evaluation against data while others are relatively new, such as Sacramento Water Allocation Model (SacWAM), may not been subjected to extensive testing and vetting. Since SacWAM is expected to be a regulatory assessment tool for reckoning flow in junctions, river mouths and smaller tributaries, it should be tested thoroughly with field data to improve the efficacy and reliability of models. Lack of field data, specifically at river mouths and tributaries, has caused heavy reliance on modeling. This is an opportunity for advocating additional monitoring needed for the success of the many Delta plans and the overall monitoring enterprise.

Balancing among species and balancing with economics.
Most native species tend to cluster in the flow patterns they need, tending to follow the natural flow approach to setting environmental flows. However, the Delta is home of one of the nation's most popular recreational fisheries, built largely on non-native species. Does the SWRCB need to balance these two beneficial uses of water? If so, what are the scientific aspects of this trade-off? Perhaps these ecosystem flows are important for this report.

Similarly, the SWRCB has some responsibility to balance environmental beneficial uses and economic benefits of water uses. What are scientific aspects of this trade-off? Perhaps these economic and other socially-desired flows will be addressed in other reports or impact statements.

2. Cold Water Habitats

The report recognizes that temperatures are fundamental for fish physiology and survival and that regulating temperatures should benefit cool-water fishes. The implementation of this recommendation is vague and largely left to be 'further evaluated'. The report should better review this practice which has been used in other ecosystems to provide some specific examples. This area also deserves some discussion of how management of this particularly limited and diminishing resource should be managed with a warming climate.

There are considerable ongoing efforts on temperature data collection, modeling, and monitoring for major rivers tributary to the Delta, which should be identified and summarized. It is likely that water management agreements will need to include real time and seasonal temperature management activities which will require such capabilities and scientific understanding, and perhaps enhancements. Identifying the agencies undertaking these efforts will be useful for those contemplating such agreements.

It is useful to note areas where scientific and technical work is likely to add new capabilities and insights in the coming few years, during which the new water quality control plan will come into effect, and during which presumably agreements will be under consideration. This information, even though not available now, is likely to become useful in the future.

3. More on Non-flow Stressors

The draft report suffers from a lack of quantitative treatment of any effects from non-flow stressors. Only fairly general narrative descriptions were provided in Chapter 4. Descriptions of quantitative assessments have been done (e.g. for pesticides, Baldwin et al. 2009), but we did not find reference to such information. Non-native invasive vegetation in the Delta also imposes various forms of direct and indirect stress on the native ecosystem, ranging from increasing water clarity affecting Delta smelt to reducing sunlight penetration and flows in some areas. Other invasive species have altered food webs and nutrient flows. These need to be addressed. Perhaps graphing fish declines across other stressors would make the point that flow is not the only driver of fish abundance and this may help manage outcome expectations. See detailed recommendations in section on Other Suggestions.

4. Management of Non-flow Stressors

Chapter 4 had little description of possible methods for reducing effects of non-flow stressors. The exception was a narrative description of control efforts for non-native vegetation, although it neglects more discussion of how vegetation affects desirable species in the Delta. Flows have many direct and indirect effects on non-flow stressors, such as affecting the extent and timing of invasive plants and residence time of contaminants and nutrients. At a minimum, efforts to reduce the impacts of other non-flow stressors and the interactions of flows with these stressors need to be further discussed. For example, statistical analyses can be insightful but suffer from predicting outcomes if some fundamental ecosystem conditions (such as invasive species) have changed underlying processes or if correlations are spurious.

A fuller organized description of non-flow stressors, the agencies that are responsible for their regulation and scientific understanding for these issues would be useful. It would better balance the fuller discussions of flow stressors and provide a better basis for connecting these with non-flow stressors in the context of negotiated agreements that the SWRCB seeks.

5. Climate Change

Given that the proposed Phase 2 regulations are supposed to be updated every three years, it would seem that climate change should not be a major issue for this regulatory process. Even if this nominally triennial review extends to 20 years or more, as it sometimes does, changes in climate are likely to be modest within this time frame. Still, there are several reasons for the scientific basis report to pay attention to changes in climate.

First, several substantial responses needed to sustain native ecosystems with climate change are likely to require near-term actions. These include the acquisition of lands and estuarine processes needed to support tidal marshes and habitats now to prepare for higher sea levels and other changes in climate. For managing cold water, the long time required for planning changes in temperature controls from dams and other infrastructure changes in response to rising temperatures might require some consideration in plans decades in advance for their operational needs.

The collection of data and scientific studies also are needed in the nearer term to better prepare ecosystem managers for changes in climate mixed with the host of other changes expected. The development of longer-term adaptability, particularly in implementation of regulations, will require preparation and strategic changes in regulatory philosophy and methods. The proposed SWRCB approach might be helpful in this way. At this stage, regulatory responses to climate change are likely to be mostly anticipatory, but could nonetheless be substantial.

We are entering a time when both management and regulations will benefit immensely from being done adaptively, with a scientific basis. Climate change is but one reason to begin on this path. The flexibility and potential diverse engagement arising from the SWRCB's approach has some advantages in this way.

Hydrologic conditions in the Delta, particularly unimpaired flow and stream temperatures, are expected to see climate change effects. This merits an expanded discussion in the SWRCB report. In Chapter 4 (p 4-1), climate change is identified as a stressor that affects fish and wildlife (p 4-16) via water supply reliability, flooding, salinity intrusions and temperature, but surprisingly no substantive discussion of climate change is included in the hydrology section. A large body of literature exists on the effects of climate change on hydrologic conditions in the Delta, though quantitative effects of climate change appear to be quite uncertain (e.g., Cayan et al. 2010; Stern et al. 2016).

While the report is intended to be above the fray of uncertainties and relies on best available science (page 1-13, para 1), it is instructive to include an explicit account of potential climate change effects on Delta hydrology and their impacts on ensuring new Delta in/out/interior flow requirements and cold water habitat needs. The plan under development proposes to maintain 'current' flows within 35% - 75% of the unimpaired flows, and there is a longer term variability of unimpaired flow (Gleick & Chalecki 1999). A discussion beyond the current focus on year-to-year variability is needed.

6. Adaptive Management

Flow regulations will continue to evolve as the Sacramento-San Joaquin Delta changes and new scientific understanding emerges. We recommend adding a substantive discussion on the use of adaptive management in the context of these new regulations and address how it will be implemented and how it might be used to address cause and effect. This section could also identify expected outcomes, alternatives and the most prominent gaps in the scientific basis and understanding developed in the report.

This discussion should include thoughts on a long-term science and technical program (including modeling) to support the SWRCB's long-term interests in the effectiveness of environmental flow regulations. A common scientific and technical program would have obvious benefits for supporting both traditional regulations and even more for the SWRCB proposals to implement regulations through broad basin agreements involving many parties. Agreements become more difficult to negotiate, implement, enforce, and improve without a common scientific and technical basis.

This is not the last time that the SWRCB will need to address flow regulations regarding the Sacramento-San Joaquin Delta, and evaluate and employ science regarding these issues. Indeed, the need to update and evaluate the science of these issues increases if the SWRCB is successful in engaging stakeholders and other agencies in soliciting more flexible regulation proposals that would also perform well for all resources.

The SWRCB might do well to:

1. Identify the most prominent gaps in the scientific basis and understanding developed in the report. Advancing fish flow understanding beyond simple particle tracking models might be one of many such items.
2. Suggest a sustained scientific and technical program for addressing these issues, probably in concert with other agencies. Some US estuaries employ ecological, flow, and water quality models to aid in system management. Temperature modeling might have special planning and real-time operation relevance.
3. Suggest a scientific program to address additional scientific and technical issues that are likely to arise in the course of implementing this round of regulatory changes and the development of more flexible operating standards in concert with stakeholders, again probably in concert with other agencies.
4. Discuss how the organization of monitoring and research might improve discussions and regulatory decisions into the future.
5. The Board is proposing a major complex program. What are thoughts on what should be done when parts go wrong, or go unexpectedly well?

Other suggestions for the document

Writing Style: Overall, the document is a vast and readable compendium of studies related to native species in the Delta and its tributaries. It was largely an informative pleasure to read. Chapter 1 provides an informative introductory guide to purpose, structure, and some of the content. Chapters 2 and 3 present important evidence systematically: differences between present-day flows and unimpaired flows (chapter 2); and relationships between flows and the abundance and distribution of selected species (chapter 3). Section 3.2 provides a synthesis of California and outside-California findings about overall relationships between fish and flows. The rationale for using percent of unimpaired flow is clearly stated (section 5.1.1).

Chapter 3 and a few other places could be relieved of some jargon and wording such as "associated with" and "experienced significant mortality". There is inconsistency in referencing statements. Some statements are well referenced but others (especially in chapter 5) were unsupported. Insertion of a figure or table number or citation would help to make a strong case for the recommendations. Amend figure captions to relate each figure and table to the main issue being addressed. It should be possible to understand most of the report by reading its abstract and studying the figures and tables. We also recommend an informative abstract of findings and recommendations. Some detailed suggestions are given in Appendix B.

The lettering in figures ranges from nearly illegible (2.1-7) to oversize (3.9-1). Format all for the clean and efficient look of Figure 3.13-1.

Scientific Content: We recommend the following to improve the scientific basis/content of the report.

At this time, the report is a living document, with improvements to be made based on public and stakeholder comments and advances of knowledge. It is recommended that the final report include a table of summary changes (to flow requirements) and underlying scientific basis. Currently, it is difficult to see the forest through the trees with regard to new changes.

The report could make a more effective case for the primacy of flows by showing, graphically, the demonstrated roles of other stressors. As one example, because vascular plant growth and distributions are related to hydroperiod and salinity (Boyer and Sugula 2015), the Delta's complex mosaic of existing wetlands would respond to increased environmental flows. The mosaic of habitats includes tidal wetlands, willow swamps and tule marshes in the Delta, salt-grass meadows of Suisun Bay, and pickleweed marshes of San Pablo and San Francisco bays, with submersed aquatic vegetation throughout shallow waters (Boyer et al. 2012, 2015). It is likely that greater plant growth would be considered positive for the regional ecosystem, because vascular plants contribute to the base of the food web and structure habitats for aquatic invertebrates (Boyer et al. 2013, 2016). Increased flows would reduce some areas of water stagnation and reduce water salinity. Most emergent halophytes tolerate salt, rather than require it in high concentrations (Borgnis and Boyer 2016, Boyer et al. 2016); thus, reduced salinity would likely stimulate growth and reproduction of emergent vegetation, and taller emergent plants might shade and cool the water, benefiting aquatic animals. Taller pickleweed would be useful to the salt marsh harvest mouse, by providing more vertical refuges from high tides. Native dominants of submersed aquatic beds are sago pondweed (*Stuckenia pectinata*), eelgrass *(Zostera marina*), and widgeon grass *(Ruppia maritima*). These might be outcompeted by invasive *Egeria densa*, which is less salt tolerant than the native sago pondweed (Borgnis and Boyer 2016). Both species' distributions could change with greater eFlows, and their associated invertebrates could also change directly with shifts in the dominant plant or indirectly through increased water temperature where dense aquatic vegetation slows water flow (Boyer et al. 2016). Potential negative effects of increased eFlows would be increased growth of existing and future invasive plants (Boyer and Sutula 2015). There is, however, potential to harvest floating plants such as hyacinth and compost their biomass, capitalizing on high productivity, nutrient-removal capacity, and thus clean the water while producing a usable byproduct (soil amendment) (G. Tchobanoglous at UCD likely has reports on the experimental hyacinth nutrient-removal system that was operated in the 1980s-90s to turn San Diego wastewater into drinkable-quality water).

In addition, the summary figure in chapter 3 (Fig. 3.13-1) could be amended to explore cause and effect. The existing figure merely brings together previously presented graphs showing overall biological declines in recent decades. These declines could be compared, in summary fashion, by stacking each species graph above a time series of flow parameters. On each flow graph, the "protective" ranges in Table 3.13-2 could be highlighted. This kind of comparison, or others, could be designed to help the reader evaluate the statement, "many of the native fish and wildlife species maintained healthy populations until the past several decades when water development intensified" (p. 1-3). The suggested comparison could also be referenced in a similar statement in the chapter on flow requirements (p. 5-2). We didn't see a graphical version of the important point made on page 1-13, about a contrast between a wet 2011 and a dry 2012–2015 as "a dramatic example of the importance of flow for native fish species." Graphs could be added to chapter 4 to relate other stressors to the observed declines in fish and invertebrate abundance. These include the effects of the invasive clam *Corbula*, highlighted on pages 3-7, 3-11, and 4-13.

Comparisons of stressors and outcomes plotting against time could also show, for reference, the dates of key efforts to improve the outcomes, such as “implementation of D-1641” (p. 1-13).

For each stream, we suggest a small table with comparable summary statistics and information such as mean annual flow, lowest flow, major hydrograph components, species composition, major reservoirs or blockages, diversions, and existing flow requirements. Some better location and descriptive maps would also help.

In the discussion of invasive and undesirable species, is there something to be said for managing flows or other conditions for suppression of undesirable species, as part of encouraging native species?

Different parts of streams might need different flow characteristics. Floodplains seem to have a disproportionate role in sustaining native fish species. Is there thought on including periods of inundation for floodplains in the standards, such as for Yolo Bypass or in the northeastern Delta. Rip-rapped edges might need different flow velocities, etc. than vegetated streams, or streams with overabundant floating or submerged vegetation.

Forewarn of differing geographic ranges: Overview Chapter 1 begins with “Sacramento River watershed and related areas” (p. 1-1). The overview could include an index map that plots the geographic ranges considered in chapters 2 and 3. The hydrology in chapter 2 covers the watershed north and east of the Delta, and also considers the Delta itself and the Suisun “region.” The “related areas” include migratory ranges that extend into the Pacific Ocean (salmon, p. 3-3) and San Pablo Bay (Longfin Smelt, p. 3-8). Species considered in detail (section 3.3) include many that depend on the estuary (p. 3-10). The “related areas” in the context of loss of tidal wetland, as a stressor, appears to exclude estuarine areas seaward of Suisun Bay (p. 4-2).

Sediment flows are important as well. Is the SWRCB prepared to discuss this? Water flows, especially floods, have a major role in mobilizing and transporting sediment.

Context and Conclusions
A diagram early in the report showing how this Scientific Basis report fits into the larger scheme of SWRCB reports and regulations would be very helpful for readers trying to see where this report ends and other reports begin in terms of coverage and issues, and how each report is to support the process of establishing environmental flows and their implementation and updating.

In the last chapter, an overall table identifying and summarizing Delta flow and export limits would be useful.

Who should document the scientific basis for regulations?

The subject of this document is not solely the concern of the SWRCB. Indeed many State, local, and federal agencies share these concerns and have substantial scientific expertise and policy responsibilities for the maintenance and management of ecosystems in the Delta estuary and upstream. It might be inefficient and unfocussed to have each agency separately develop documents on the best available science for each agency purpose, particularly for major issues of common concern. The SWRCB and other agencies should consider how the science of the Delta and related areas could be more effectively coordinated.

Conclusions

Overall, we find the SWRCB's "Working Draft Scientific Basis Report for New and Revised Flow Requirements on the Sacramento River and Tributaries, Eastside Tributaries to the Delta, Delta Outflow, and Interior Delta Operations" to be a useful and largely readable compendium of the existing scientific understanding of how native fish populations are likely related to flows and other potential stressor for this region. We identified some areas of the initial draft document that will benefit from substantial improvement.

The most difficult gap to fill might be placing the work in a broader context. At the front end, this scientific basis report should be placed in the context of the SWRCB's other documents and procedures. The SWRCB's emphasis on implementing its new regulations via regional agreements also implies additional discussion and text on how scientific and technical aspects of these agreements should be handled in order to support, sustain, and improve such agreements over time and over a range of other non-flow stressors and regulatory authorities.

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Appendix A – Responses to Specific Questions from the SWRCB

1. *Does the DISB concur with the working draft Scientific Basis Report determinations that:*
    a) *The present flow regimes in the Bay-Delta and its watershed are not adequate to protect fish and wildlife beneficial uses,*
    b) *There is sufficient information to develop new and revised flow requirements for the reasonable protection of fish and wildlife beneficial uses, and*
    c) *The most current science is being used to make those determinations?*

    a) Yes, a strong case is made that flows are not adequate but improved flows alone might be insufficient for some species. For some species, there is reason to think that even more comprehensive efforts might be insufficient to preserve them in the wild.
    b) Yes, as a start. It will be desirable and necessary to revise definition of the scientific basis with time and discuss the process by which this might be done and sustained.
    c) Yes, this appears to be generally true.

2. *Does the working draft Scientific Basis Report demonstrate:*
    a) *The importance of flow in supporting ecosystem processes that benefit salmonids, smelts, and other native fish and invertebrate species in the Estuary and its tributaries,*
    b) *The relationships between flows and the distribution and abundance of native fish and invertebrate species?*

    a) Yes. Compelling empirical, mechanistic, and theoretical evidence is provided to support the general importance of flows as a factor that supports a range of native species and ecosystem functions. Also, as the document points out, flow is unlikely to be the only factor affecting these species.
    b) Yes, in general, but relationships between flows and abundance of native species are not simple or unchanging or even well-defined. Some greater effort should be made to identify the most important gaps in knowledge here, and discuss how the SWRCB and others might contribute to reducing these and additional gaps over time.

3. *Does the working draft scientific adequately:*
    a) *Acknowledge aquatic ecosystem stressors other than flow and how they interact in the ecosystem?*
    b) *Demonstrate that an approach that integrates flow conditions with reductions of other stressors could be needed to protect fish and wildlife beneficial uses?*

    a) Yes, other stressors are acknowledged but further discussion seems warranted.
    b) Yes. The draft sets the stage for this well, but does not go much farther. This is a difficult thing to do. The report, or some other report, might discuss how this integration might occur from scientific, technical, operational, financial, legal, and institutional perspectives.

4. *Do the timing and magnitude of flows recommended for consideration in the remainder of the Phase II process capture a sufficiently wide range to inform the decisions that the State Water*

Board must make in considering new and revised flow requirements for the reasonable protection of fish and wildlife beneficial uses?

Mostly yes. The range of flows seems relevant, but the analysis for this range entails some major unavoidable uncertainties. Some discussion of how to reduce and better deal with uncertainties over time should be included.

5. Does the use of a percent of unimpaired flow as a "bank account," with the allowance for flow shaping and shifting to provide functional environmental flows provide an appropriate method for reasonably protecting fish and wildlife beneficial uses?

Yes, such a water budget for the environment is an attractive accounting approach, although perhaps not the only one available. As an accounting approach, it might serve well to support other approaches to managing water for native ecosystems. A comparative discussion with other approaches might be useful, as well as some discussion of how it might be practically implemented.

6. The State Water Board appreciates that scientific understanding of the effects of flow and other stressors on aquatic species is continually evolving. The State Water Board intends to structure new and revised flow requirements to reasonably protect fish and wildlife while providing the flexibility necessary to accommodate adaptive management. Please comment on the critical features that must be included to make adaptive management work in this context.

Some features to add to bring adaptive management in more explicitly might include:

- Identification in the document of major perceived current uncertainties
- Discussion or plans for performance-based and scientific monitoring and data gathering
- Ecosystem modeling for integrating and testing existing and new information in a larger context
- Discussion of the organization of science, management, and regulatory functions to implement adaptive management, and identification of resources to support it.
- Some discussion of what should be done if things go wrong, or if they go unexpectedly well.

Appendix B: Comments by page number (hyphen) or section number (period)

1-12 – On choosing 35 percent of unimpaired flow as a lower bound: The explanations I noticed are in the second paragraph of page 1-12 and the last paragraph of page 1-13. The explanation on page 1-13 appears to say that 35 percent is "no less than current conditions." The report's premise, however, is that "Recent Delta flows are insufficient to support native Delta fishes in today's habitats" (p. 1-5).

2-7 – The map shows a mix of landform units and depositional units. One of the depositional units is known only from the subsurface. How this fruit salad relates to the hydrology might be stated in the caption. Figure A-1 (p. A-4) may be more useful here, particularly if the numbers there are keyed to a list of the drainage basins considered in section 2.2.

2.2 – The systematic descriptions in section 2.2 would be clearer if each catchment considered had its own index map showing all the place names mentioned. A report this important needs to be readily understandable to readers unfamiliar with this geography.

2-13 – The story told in Figure 2.2-2, and on others where discharge records go back before the Projects, might be clarified by adding a graph with water years on the x-axis and measures of discharge on the y-axis. This kind of time series lends itself to comparison with outcomes for fish.

2-54 – The salinity of the gulp from levee breaks might be expected to vary with levee location and time of year.

2.7 – As a rule of thumb, an abstract has 5 percent of a report's length. This concluding section adds up to about 1 percent of the chapter's length. The point being that there's room to provide a meatier set of conclusions than is offered here – to provide conclusions more nearly as thorough and informative as those in section 3.13.

3-58 – The life histories of the most important species analyzed might be plotted in a diagram combining space (map or maps), time, and the changing form of the animal. This kind of figure would help make chapter 3, which is so important and thorough, more accessible to a broad audience.

3-86 – The set of graphs would tell the story of decline more clearly if their time axes were identical and the abundance axes perhaps at a common scale as well. Also, where the trawl index has been replicated, do the ranges extend beyond the sizes of the dots? With those internal details taken care of, the graphs would be all the more ready for comparison with flows, other stressors, and prior management actions.

3-90 – This table, and the two that immediately follow, provide excellent summaries. As suggested above, the protective ranges in Table 3.13-2 could be usefully plotted in graphs that show how the abundance of each species has varied with flows and other stressors in those recent decades "when water development intensified" (p. 1-13).

4-1 – Supporting references could be helpful with the sentence beginning, "The benefits of flows are enhanced . . ."

4.2.1 – Could be broadened in scope and edited for clarity of thought and expression. The tidal wetlands (subsumes tidal swamps, where woody plants predominate) of interest are not just freshwater but also brackish (Suisun) and may extend as well into San Pablo Bay. How does the Delta currently "support" certain acreage of tidal wetland? Which of the "environmental challenges" is truly "changing" Suisun Marsh? If marsh restoration is reducing tidal energy, how much tidal energy was available at the time of the Gold Rush, before diking of most of the estuary's tidal wetlands?

4-2 – The "multiple fauna" sentence needs a different supporting reference, perhaps Whipple et al. 2012.

4-3 – Figure 4.2-1 tells a familiar story without relating it to fish or flows. It may be more informative to plot wetland loss against time, in a stack of graphs showing concurrent trends in fish and discharge.

4.43 – The plants considered are aquatic only. There are also invasive plants of concern in tidal marshes north of Suisun Bay.

4-18 – The conclusion to Chapter 4 could summarize, in words and more, the roles that other stressors have likely played in the declines illustrated on page 3-86.

5.2.2 – The citing of chapter here (and elsewhere; "As discussed in Chapter 3") could be made more specific by citing verse as well (page, figure, table). Hyperlink if possible.

Appendix C – Responses to other questions

Supplied by Dan O'Hanlon:

For each water quality objective (or, if applicable, period of time the objective might control) that is intended to protect or benefit fish and wildlife beneficial use(s):

Understanding the Science in the Context of all Factors Affecting the Beneficial Use(s)

1. *Does the report adequately present the scientific basis in the context of the species' full life cycle? If not, what elements of the species' life cycle is the report lacking?*

2. *Does the report discuss the stressor(s) involved, how the stressor(s) involved affect a biological mechanism(s), and the basis (science, conceptual model, hypothesis) for assuming a relationship between the stressor(s) and the mechanism(s)?*

3. *Does the report adequately identify uncertainties in the science and the likelihood the benefit(s) will be realized (uncertainties could include, but should not be limited to, statistical uncertainties and uncertainties in future environmental conditions)?*

The report could identify science gaps and uncertainties a bit better. In some of the regression analyses, some initial uncertainty analysis should be easy.

4. *Does the report identify testable conceptual models or hypotheses that would enable investigators to better understand the uncertainties?*
If not, what are the testable conceptual models or hypotheses that can be identified from the scientific literature?

5. *Does the report identify the anticipated result(s), both qualitative and quantitative?*

A little.

6. *Does the report adequately identify the monitoring program needed to evaluate the expected outcomes?*

No. This might be too soon.

Scientific Information Relied Upon

7. *Does the report reflect current scientific information/lessons learned from prior management actions?*

Mostly.

8. *Does the report adequately identify the science relied upon and any science that may contradict the findings or conclusions presented? If not, what scientific report(s) should be cited?*

Contradicting science is not explicitly identified.

<u>Presentation of Science to Inform Decision</u>

9. *Is there an alternative methodology/approach that would provide similar levels of benefit/protection or greater certainty with less cost to water resources?*

Good question. This is not assessed, but merits some discussion. Analysis on this might be premature.

10. *Does the report incorporate adequately the structured decision-making required to support development of adaptive management and necessary monitoring to support adaptive management?*

Not yet.